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Extended Abstract

The Evaluation of Structural Properties and Release Behavior of D-limonene Nanoencapsulated with *Alyssum Homolocarpum* Seed Gum Applying Electrospraying

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Abstract

In this study *alyssum homolocarpum* seed gum (AHSG) nanocapsules containing D-limonene were fabricated by electrospraying process. For this purpose, D-limonene emulsions with constant AHSG (0.5% w/w) and two different flavor concentrations (10 or 20% based on gum weight) were prepared. The effects of physical properties of emulsions (rheological properties, droplet size, surface tension and electrical conductivity) on the morphology of capsules were studied. The results indicated that the droplet size and electrical conductivity of emulsions was mainly affected by concentration of D-limonene. Consequently, morphology and particle size of nanocapsules obtained from two emulsions, were somewhat different due to their difference in flavor content. FE-SEM images confirmed the success of electrospraying process for production of round and smooth AHSG nanocapsules with narrow size distribution. AHSG nanocapsules showed high encapsulation efficiency (more than 87%). Stability assay revealed a relatively good storage stability of encapsulated D-limonene and the maximum loss in 90 days was 11.67%. The release of D-limonene from AHSG nanocapsules was performed quickly, completely and fairly uniform due to the small and uniform size of particles. The kinetic modeling indicated that the data of D-limonene release in both artificial saliva and deionized water media were well fitted to the Korsmeyer-Peppas models.

Keywords: *Alyssum homolocarpum* seed gum, Electrospraying, Kinetic modelling, Nanoencapsulation, Release

Introduction

Recently, nanoencapsulation of bioactive compounds is taken into consideration because of the greater surface area to volume ratio of nanoparticles, which improves encapsulation efficiency, solubility, bioavailability and controlled release of the encapsulated ingredients (Ghorani & Tucker, 2015). Electrospraying is a novel and simple technology to produce nano-scaled particles, which is based on the application of the high electrostatic potential to overcome surface tension force of a polymer solution (Tapia-Hernández *et al*., 2015).

Extended Abstract

Electrospraying is considered suitable for encapsulation of sensitive food ingredients because severe conditions such as temperature are not required in this method (López-Rubio & Lagaron, 2012). Alyssum homolocarpum seed gum (AHSG) is a novel potential source of hydrocolloid that has never been used as a carrier for encapsulation of food ingredients. Previous studies have shown that AHSG solution exhibits high viscosity at low shear rates, and has an anionic feature (Hesarinejad, Razavi, & Koocheki, 2015; Koocheki, Kadkhodaee, Mortazavi, Shahidi, & Taherian, 2009). These properties seem to favor the development of AHSG capsule through electrospraying. According to these descriptions, AHSG was selected for nanoencapsulation of D-limonene –as a sensitive flavor– through electrospraying process.

Materials and methods

AHSG nanocapsules were prepared by electrospraying of emulsions containing 0.5% gum, 0.1% Tween 20, and 10 or 20% D-limonene under the applied voltage of 20 kV and flow rate of 0.1 mL/h (Khoshakhlagh, Mohebbi, Koocheki, & Allafchian, 2018). The effects of physical properties of emulsions (rheological properties, droplet size, surface tension, and electrical conductivity) on the morphology of capsules were studied. Nanocapsules were characterized in terms of morphology using FE-SEM, encapsulation efficiency using UV-visible spectrophotometric method (Kaushik & Roos, 2007) and stability during 90 days of storage at 4 and 25 °C. The release profiles of encapsulated D-limonene were evaluated in two release media (deionized water and simulated saliva). Finally, to examine the mass transport mechanisms of incorporated limonene, the release profiles were fitted to various kinetic models.

Results and discussion

Rheological tests showed that both emulsions (10 and 20% D-limonene) had strong pseudoplastic behavior (Vardhanabhuti & Ikeda, 2006). The flow behavior index and consistency coefficient of emulsions were not affected by D-limonene concentration. Besides, surface tension of emulsions did not show a marked change with by increasing the oil loading to 20%. However, electrical conductivity and droplet size of emulsions were dependent on the limonene concentration. Consequently, morphology and particle size of nanocapsules obtained from two emulsions were somewhat different due to their difference in droplet size and conductivity properties. However, both emulsions produced spherical nanocapsules with a narrow size range of 35-85 nm. AHSG nanocapsules loaded 10 or 20 % limonene showed high encapsulation efficiency (87-93%) and low oil surface content (1.07-6.19%). Stability assay showed that AHSG nanocapsules provided relatively good storage stability and maintained more than 88% of the initial loaded D-limonene during 90 days of storage at 4 and 25 °C. The release of limonene from AHSG nanocapsules was performed relatively quickly. Hydrophilic nature of AHSG was probably the reason of the rapid flavor release due to high water absorption capacity of AHSG and thus rapid matrix dissolution. The rate of release profiles was influenced by type of release medium. A faster flavor release was observed in deionized water compared to the artificial saliva. It shows that hydrocolloidal matrix of nanocapsules will degrade faster in water than saliva. In addition, the slower flavor release from 10% D-limonene loaded nanocapsules was observed than 20% loaded samples in both mediums. The faster release rate of 20% loaded capsules could be attributed to the steeper gradient concentration of limonene within this sample and release medium compared to the 10% loaded samples (Hosseini *et al*., 2013). The release data were fitted to four various kinetic models. It was found that the release data were well fitted to the Korsmeyer-Peppas models with R^2 values greater than 0.96. The release mechanisms of limonene were evaluated based on the n value in this model. Results indicated that D-limonene release in water medium followed an erosion-controlled process. While flavor release in artificial saliva exhibited an anomalous transport, thus diffusion and polymer erosion coincided in this medium.

Conclusions

In this study, AHSG nanocapsules containing D-limonene were successfully fabricated by electrospraying process. The morphology of nanocapsules was mainly affected by droplet size and electrical conductivity of emulsions. High encapsulation efficiency and also high storage stability of encapsulated limonene were the most important advantages of AHSG electrosprayed nanocapsules. Release study and kinetic modeling revealed that limonene release from AHSG nanocapsules in saliva is mostly governed by the coupled diffusion and capsule erosion mechanisms.

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